HOST CHECKLIST OF ROOT-KNOT NEMATODES ON BROAD-LEAVED LANDSCAPE TREES

by Frank S. Santamour, Jr. and Janet McCray Batzli

Abstract. A comprehensive review of the world literature dealing with root-knot nematodes (Meloidogyne spp.) on landscape trees is presented, including both natural occurrence and positive and negative results of controlled inoculations. Information is provided on more than 120 species in 56 plant genera.

Résumé. Une revue détaillée de la littérature mondiale s'intéressant aux nématodes des racines (Meloidogyne spp.) sur les arbres d'ornement est présentée, incluant la présence naturelle et les résultats positifs et négatifs d'inoculations contrôlées. Des renseignements sont fournis sur plus de 120 espèces de 56 genres de plantes.

Earlier this year, we published (65) the results of our rather extensive studies of root-knot nematodes (Meloidogyne spp.) on willows (Salix spp.). While we were surveying the world literature on this topic, it became obvious that although there had been numerous reports of root-knot nematodes on woody plants there were also great gaps in our knowledge of the exact identity of the pest and host species. Furthermore, it was apparent that there would be opportunities for significant observational and experimental research in this field if persons working with trees were aware of past investigations.

All of the root-knot nematodes are currently classified in the genus Meloidogyne. Although the genus had been established by E.A. Goeldi in 1887 for M. exigua (on coffee trees in Brazil), subsequent authors placed other root-knot nematodes under the genera Anguillula, Caconema, Heterodera, and Oxyuris. It was not until 1949 (14) that B.G. Chitwood re-established the genus, redescribing M. exigua (Goeldi) Chitwood, M. arenaria (Neal) Chitwood, M. incognita (Kofoid and White) Chitwood, and M. javanica (Treub) Chitwood and describing a new species (M. halpla Chitwood). These are still considered the most widespread and destructive root-knot nematodes throughout temperate zones around the world. Their host ranges include herbaceous and woody plants in field, orchard, and forest, but major research efforts have been restricted to important economic crops such as tobacco, tomato, potato, soybean, strawberry, and cotton.

Some morphological variants of these species have been described as subspecies or varieties, usually expressed as trinomials: M. arenaria thamesi, M. incognita acrita, and M. javanica bauruensis. In the 1976 compendium of Esser, et al. (20), these three subspecific taxa were elevated to species rank.

A somewhat more biologically important classification has been developed by Sasser (66), who distinguished "races" among these species based on their ability to infest and reproduce on different host plant cultivars. He recognized four races of M. incognita, two of M. arenaria, and only a single race of M. hapla and M. javanica. A further differentiation of two races of M. hapla was made by Triantaphyllou and Hirschmann (76) on the basis of chromosome numbers and mode of reproduction. Sasser (66) stated that the host races of M. arenaria and M. incognita were morphologically indistinguishable (within species). It is of some interest that the culture of M. arenaria that Chitwood (14) obtained from W.H. Thames (M. arenaria thamesi) did not infect peanut and, perhaps, could be equated with M. arenaria (Race 2) of Sasser (66). Despite these studies on morphology, cytology, and host preference, most of the current nematological research is concerned with the utilization or identification of these organisms at the species level.

Of the 35 Meloidogyne "species" listed by Esser et al. (20) in 1976, only three new species had been reported on woody host genera commonly grown in the United States. These were M. brevicauda Loos on tea (Camellia sinensis (L.) Kunze) in 1953 in Ceylon (41), M. ovalis Riffle on sugar maple and other trees in 1963 in Wisconsin (60), and M. mali Itoh, Ohshima, and Ichinohe on apple (Malus) and other trees in 1969 in Japan (34). Neither M. brevicauda nor M. mali have been found in the United States but M. ovalis has been subsequently reported from Iowa (57).

Since 1976, several new Meloidogyne species
have been reported on woody hosts. Golden (24) described *M. camelliae* Golden on *Camellia japonica* L. imported from Japan and *M. querciana* Golden on pin oak (*Quercus palustris* Muenchh.) from Virginia (1979). Hirschmann (32), in 1982, described *M. platani* Hirschmann from sycamore (*Platanus occidentalis* L.) in Virginia and *M. christi* Golden and Kaplan (25) was reported on *Quercus laevis* Walt. in Florida in 1986.

Based on inoculation studies conducted by the nematologists who described these new root-knot nematodes from woody plants, these *Meloidogyne* species have a restricted host range and do not parasitize many herbaceous crop plants. Thus, it is likely that more "new" nematode species will be discovered on woody plants. Some may be found on trees or shrubs previously reported as hosts of "unidentified" *Meloidogyne* species and some could be found on woody plants not previously noted as hosts of any root-knot nematodes.

The compendia issued by the Commonwealth Agricultural Bureaux and other agencies in England [(28)—1940; (26)—1959; (27)—1965] and that of Ruehle (62) in 1967 were invaluable in preparing this checklist. However, insofar as it was possible, all primary references were obtained and checked for accuracy, especially with regard to the nomenclature of host plants. Some original references could not be obtained and these are noted in "Literature Cited".

This checklist is presented to stimulate arborists, horticulturists, and nurserymen to be more aware of the potential damage caused by root-knot nematodes, to "look underground" when investigating the causes of poor plant performance, and to help in extending our knowledge of the diversity and distribution of these plant pests.

In this checklist, the plant species are recorded as being "noted hosts" or "natural hosts" of identified or unidentified or unidentified root-knot nematodes. We have tried to restrict the use of "natural host" to those situations where a particular nematode was found to be capable of completing its life cycle (to reproduce) on the host. The term "noted host" denotes only that root galls were observed.

**Acer**

A. *japonicum* Thunb.—Noted host of unidentified *Meloidogyne* sp. intercepted in USA on plants from Japan (71).

A. *macrophyllum* Pursh—Noted host of unidentified *Meloidogyne* sp. in Oregon (9).

A. *negundo* L.—Susceptible to inoculation with *M. ovalis* (60, 61). Noted host of unidentified *Meloidogyne* sp. in USSR (78).

A. *palatum* Thunb.—Noted host of *M. mali* in Japan (34).

A. *platanoides* L.—Susceptible to inoculation with *M. ovalis* (60, 61). Noted host of unidentified *Meloidogyne* sp. on nursery stock imported into Finland (39).

A. *rubrum* L.—Susceptible to inoculation with *M. ovalis* (60, 61). Not susceptible to inoculation with *M. arenaria, M. hapla, M. incognita*, or *M. javanica* (64); or *M. platani* (32). Noted host of unidentified *Meloidogyne* sp. in Tennessee (63).

A. *saccharum* Marsh.—Natural host of *M. ovalis* in Wisconsin and susceptible to inoculation (60, 61). Symptoms included chlorotic foliage, twig dieback and plant death.

**Aesculus**

A. *hippocastanum* L.—Noted host of unidentified *Meloidogyne* sp. on nursery stock imported into Finland (39).

**Albizia**

A. *julibrissin* Durazz.—Susceptible to inoculation with *M. arenaria* and *M. arenaria thamesi*; formed galls with *M. hapla*, but no egg masses; not susceptible to inoculation with *M. incognita, M. incognita acrita*, or *M. javanica* (67). Heavy galling noted with *M. javanica* and slight galling with *M. incognita* (23).

A. *lebbeck* Benth.—Natural host of *M. javanica* in Africa (47). Other tropical species are also hosts of *M. incognita*.

**Alnus**

A. *japonica* Sieb. & Zucc.—Noted host of unidentified *Meloidogyne* sp. on imported stock in Maryland (73).

**Betula**

B. *allegheaniensis* Britt.—Susceptible to inoculation with *M. ovalis* (60, 61).

B. *maximowicziana* Regel—Noted host of *M. mali* in Japan (69).

B. *nigra* L.—Natural host of unidentified *Meloidogyne* sp. in Georgia (63). Not susceptible to inoculation with *M. ovalis* (61).

B. *papyrifera* Marsh.—Susceptible to inoculation with *M. ovalis* (60, 61).

**Broussonetia**

B. *kazinoki* Sieb.—Noted host of unidentified *Meloidogyne* sp. (12).

B. *papyrifera* (L.) Vent.—Noted host of unidentified *Meloidogyne* sp. in Florida (55).

**Camellia**

C. *japonica* L.—Noted host of *M. camelliae* on material sent to USA from Japan and susceptible to inoculation (24).

C. *sinensis* (L.) Kunze—"Tea"—Noted host of four major *Meloidogyne* sp. and also of *M. brevicauda* Loos in Ceylon (41).
Camellia sp.—Noted host of *M. incognita acrita* in South Carolina (5) and of unidentified *Meloidogyne* sp. in Texas and Georgia (5), and North Carolina (31).

**Carpinus**

*C. betulus* L.—Noted host of unidentified *Meloidogyne* sp. in Italy (77).

**Carya**

*C. illinoensis* (Wang.) K. Koch—Noted host of *M. incognita acrita* in Alabama (5).

**Celtis**

*C. ovata* Don—Noted host of unidentified *Meloidogyne* sp. in Maryland (46).

**Catalpa**

*C. bignoniodes* Walt.—Noted host of unidentified *Meloidogyne* sp. in USSR (78) and Israel (49).

**Castanea**

*C. crenata* Sieb. & Zucc.—Noted host of *M. mali* in Japan (34).

**Celastrus**

*C. clematitis* Mill.—Noted host of unidentified *Meloidogyne* sp. in Georgia (5).

**Clerodendron**

*C. speciosa* (Sweet) Nakai—Noted host of unidentified *Meloidogyne* sp. (81).

**Clerodendron**

*C. trichotomum* Thunb.—Noted host of unidentified *Meloidogyne* sp. (13).

**Corylus**

*C. crenata* Thunb.—Noted host of *M. arenaria* in Georgia (5), of *C. ovata* Mill.—Noted host of unidentified *Meloidogyne* sp. (10).

**Cydonia**

*C. oblonga* Mill. (=*C. vulgaris* Pers.)—Noted host of unidentified *Meloidogyne* sp. (10, 49).

**Celtis**

*C. ovata* Don—Noted host of unidentified *Meloidogyne* sp. in Maryland (46).

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**Dalbergia**

*D. sisso* Roxb.—Natural host of *M. javanica bauruensis* in Israel (51).

**Diospyros**

*D. kaki* L.—Noted host of unidentified *Meloidogyne* sp. (10).

**Elaeagnus**

*E. alatus* (Thunb.) Sieb.—Noted host of unidentified *Meloidogyne* sp. (5).

**Euonymus**

*E. alatus* (Thunb.) Sieb.—Noted host of unidentified *Meloidogyne* sp. (5).

**Elaeagnus**

*E. alatus* (Thunb.) Sieb.—Noted host of unidentified *Meloidogyne* sp. (5).

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**Elm**

*E. angustifolia* Nutt.—Noted host of unidentified *Meloidogyne* sp. (81).

**Fraxinus**

*F. americana* L.—Natural host of *M. ovalis* in Wisconsin (60), but no egg masses were found following artificial inoculation (61). Susceptible to inoculation with *M. platani* showing moderate to high galling and moderate egg production (1, 32). Noted host of unidentified *Meloidogyne* sp. in USSR (78). *F. mandshurica* Rupr.—Noted host of unidentified *Meloidogyne* sp. (13).

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*F. americana* L.—Natural host of *M. ovalis* in Wisconsin (60), but no egg masses were found following artificial inoculation (61). Susceptible to inoculation with *M. platani* showing moderate to high galling and moderate egg production (1, 32). Noted host of unidentified *Meloidogyne* sp. in USSR (78). *F. mandshurica* Rupr.—Noted host of unidentified *Meloidogyne* sp. (13).

**Fraxinus**

*F. oxycarpa* Willd. (=*F. oxyphylla* Bieb.)—Natural host of *M. javanica* in Israel (50).

**Ginkgo**

*G. biloba* L.—Noted host of unidentified *Meloidogyne* sp. in Mississippi (72).

**Gleditsia**

*G. triacanthos* L.—Noted host of unidentified *Meloidogyne* sp. in USSR (78). Not susceptible to inoculation with *M. ovalis* (61).

**Ilex**

*I. cornuta* Lindl. ‘Dwarf Burbford’ and ‘Rotunda’—Noted host of *M. arenaria* following artificial inoculation (8).

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*I. cornuta* Lindl. ‘Dwarf Burbford’ and ‘Rotunda’—Noted host of *M. arenaria* following artificial inoculation (8).
Malus

*M. ovalis* sp.—Not susceptible to inoculation with *M. arenaria* following artificial inoculation (8).

*M. sylvestris* and *M. incognita* and *M. javanica* Mill.—Noted host of *M. azedarach* L—Noted host of unidentified sp. in Japan (34).

*M. mali* in Japan (34). (Reg.) Rehd.—Noted host of *M. mali* Mill.—Noted host of unidentified *Meloidogyne* sp. (10, 13).

*M. mali* (Willd.) Borkh.—Noted host of *M. prunifolia* in Japan

*M. grandiflora* Borkh.—Noted host of unidentified *Meloidogyne* sp. in Florida (13), 55).

J. *cinerea* L.—Noted host of *M. opaca* in Iowa (57). Noted host of unidentified *Meloidogyne* sp. (13).

J. *regia* L.—Noted host of *M. javanica* in Israel (53) and of *M. arenaria* in Czechoslovakia (74). Noted host of unidentified *Meloidogyne* sp. in Florida (55).

J. *rupesstris* Engelm.—Noted host of unidentified *Meloidogyne* sp. in Arizona (10).

Koelreuteria

*K. paniculata* Laxm.—Noted host of unidentified *Meloidogyne* sp. in USSR (68).

Laburnum

*L. anagyroides* Medic.—Noted host of *M. hapla* in Maryland; based on soil samples, not galls (44).

Liquidambar

*L. styraciflua* L.—Not susceptible to inoculation with *M. arenaria*, *M. hapla*, *M. incognita*, *M. javanica* (64), or *M. platani* (1, 32). Noted host of unidentified *Meloidogyne* sp. in Mississippi (5, 81).

Liriodendron

*L. tulipifera* L.—Natural host of *M. javanica* in Georgia and susceptible to inoculation (64). Symptoms included wilting and stunted growth of seedlings. Not susceptible to inoculation with *M. arenaria*, *M. hapla*, *M. incognita* (64), or *M. platani* (1, 32).

Magnolia

*M. grandiflora* L.—Noted host of unidentified *Meloidogyne* sp. in Georgia (45).

*Magnolia* sp.—Noted host of unidentified *Meloidogyne* sp. in Florida, Georgia (5), and Arizona (11).

Malus

*M. baccata* (L.) Borkh.—Noted host of unidentified *Meloidogyne* sp. on nursery stock imported into Finland (39).

*M. x domestica* Borkh.—Noted host of unidentified *Meloidogyne* sp. on nursery stock imported into Finland (39).

*M. prunifolia* (Willd.) Borkh.—Noted host of *M. mali* in Japan (34).

*M. pumila* Mill.—Noted host of *M. mali* in Japan (34).

*M. sieboldii* (Reg.) Rehd.—Noted host of *M. mali* in Japan (34).

*M. sylvestris* Mill.—Noted host of *M. incognita* and *M. javanica* on Norfolk Island, Australia (38); and (as *Malus mitis*) an unidentified *Meloidogyne* sp. in Israel (49).

*Malus* sp.—Not susceptible to inoculation with *M. ovalis* (61).

Melia

*M. azedarach* L.—Noted host of unidentified *Meloidogyne* sp. in USA (10, 11, 12).

Morus

*M. alba* L.—Natural host of *M. javanica* in Queensland, Australia (17). Noted host of *M. incognita* in Iraq (33) and an unidentified *Meloidogyne* sp. in Israel (49).

*M. bombycis* Koidz.—Noted host of *M. mali* in Japan (34).

*M. indica* L.—Noted host of *M. javanica* in northern India (56).

*M. nigra* L.—Noted host of unidentified *Meloidogyne* sp. (10, 13).

*M. rubra* L.—Noted host of unidentified *Meloidogyne* sp. (10, 13).

*Morus* sp.—Natural host of *M. arenaria* and noted host of *M. hapla*, *M. incognita acrita* (51) and *M. javanica* (52) in Israel.

Paulownia

P. *fortunei* Hemsli.—Susceptible to inoculation with *M. incognita* (80).

Pistacia

P. *vera* L.—Noted host of *M. incognita* in Iraq (33) and an unidentified *Meloidogyne* sp. in California (37).

Platanus

P. *x acerifolia* (Ait.) Willd.—Natural host of unidentified *Meloidogyne* sp. in Washington, DC (15); later identified as *M. platanii*.

P. *occidentalis* L.—Natural host (nursery origin) of *M. platanii* in Virginia and susceptible to inoculation (1, 32). Not susceptible to inoculation with *M. arenaria*, *M. hapla*, *M. incognita*, or *M. javanica* (64).

Populus

P. *alba* L.—Natural host of *M. javanica* in Israel (50).

P. *deltoides* Marsh.—Natural host of unidentified *Meloidogyne* sp in South Carolina (63).

P. *heterophylla* L.—Not susceptible to inoculation with *M. arenaria*, *M. hapla*, *M. incognita*, or *M. javanica* (64).

*Populus* sp.—Noted host of *M. incognita* and *M. incognita acrita* in Israel (51).

Prunus

P. *amygdalus* Batsch.—"Almond"—Noted host of *M. hapla* (52), *M. incognita* (50, 51), *M. incognita acrita* (43, 51), and *M. javanica* 21, 75).

P. *armeniaca* L.—"Apricot"—Noted host of *M. incognita acrita* and *M. javanica* (43).

P. *avium* L.—"Sweet Cherry"—Noted host of unidentified *Meloidogyne* sp. (12).

P. *cerasifera* Ehrh.—"Cherry Plum"—Noted host of unidentified *Meloidogyne* sp. (55).

P. *cerasus* L.—"Sour Cherry"—Noted host of *M. hapla* (44) and *M. javanica* (50).

P. *davidiana* (Carr.) Franch.—Noted host of unidentified *Meloidogyne* sp. (13).

P. *domestica* L.—"Plum"—Noted host of *M. incognita* in Iraq (33), and of unidentified *Meloidogyne* sp. (11, 55).

P. *japonica* Thunb. Noted host of unidentified *Meloidogyne* sp. (55).

P. *mahaleb* L.—Noted host of unidentified *Meloidogyne* sp. (59).

P. *persica* (L.) Batsch.—"Peach"—Abundant literature; not included here.

P. *serotina* Ehrh.—Not susceptible to inoculation with *M. ovalis* (61).
**P. virginiana** L.—Noted host of unidentified *Meloidogyne* sp. (10, 13).

**P. yedoensis** Matsum.—Natural host of *M. mall* in Japan (34).

**P. communis** L.—Noted host of unidentified *Meloidogyne* sp. (10, 13).

**P. virginiana** Nee—Noted host of unidentified *Meloidogyne* sp. (10, 13).

**P. virginiana** Walt.—Natural host of *M. christiei laevis* (25).

**P. virginiana** Veitchiorum—Noted host of unidentified *Meloidogyne* sp. (24).

**P. virginiana** L.—Susceptible to inoculation with *R. pseudoacacia* in Oklahoma (5). Small galls were uniformly distributed throughout root system.

**S. saponaria** sp.—Noted host of unidentified *Meloidogyne* sp. (10).

**S. aluminium** L.—Noted host of unidentified *Meloidogyne* sp. (12).

**S. alata** Nakai.—Noted host of unidentified *Meloidogyne* sp. (13).

**S. virginica** L.—Natural host of *M. ovalis* and susceptible to inoculation with *M. ovafts* (61). Noted host of unidentified *Meloidogyne* sp. (10).

**S. procera** Salisb.—Noted host of unidentified *Meloidogyne* sp. (10).

**S. pumila** L.—Noted host of unidentified *Meloidogyne* sp. in USSR (79).

**S. americana** L.—Natural host of *M. ovalis* in Wisconsin (60). Noted host of unidentified *Meloidogyne* sp. in Oklahoma (5, 12) and Israel (49).

**U. americana** L.—Noted host of unidentified *Meloidogyne* sp. on nursery stock imported to Finland (39).

**U. pumila** sp.—Noted host of *M. renaria* and *M. Incognita* in the Netherlands (59) and an unidentified *Meloidogyne* sp. in Oklahoma (12).

**Z. serrata** (Thunb.) Makino—Noted host of *M. incognita* and *M. javanica* in Taiwan (79).

**Z. murrayana** Willd.—Noted host of unidentified *Meloidogyne* sp. in Southern Rhodesia (35).

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